Swift and Concurrency

The Plan for World Domination

Domains

- **Apple platform GUI apps**
- Server-side
- Machine Learning
- Systems Programming
- 🌍**World Domination**⚔️

What is Concurrency

- Parallel
  - Doing multiple pieces of work at the same time
- Async
  - Work that doesn't block the calling thread
- Concurrency
  - Doing more than one piece of work at a time, with overlapping and non-overlapping work
  - Preventing unnessary waiting
- Atomicity/atomic/non-atomic

Atomicity is a safety measure which enforces that operations do not complete in an unpredictable way when accessed by multiple threads or processes simultaneously.

— source

Why concurrency

- Performance
- Responsive UI
- More cores, fewer clock-speed improvements

Common Problems

- Readability/Maintainability
- Performance
  - Thread-switching cost
  - Memory usage
- Bugs
  - Data races
  - Deadlock

Current State

- ✅ Threads, semaphores, and locks
- ✅ Queues & DispatchGroups
- ✅ Callbacks
- ✅ Reactive/FRP (RxSwift, Combine, ReactiveSwift)
- ✅ Promises (SwiftNIO, PromiseKit, Combine.Future)
- ⌛ General Concurrency (Tasks)
- ⌛ Async/await
- ⌛ Actors

New Features

— Roadmap

— Async/Await

— Tasks

— Actor Model

Async/await

- Callbacks (completion handlers) are
  - complex
  - error-prone

```swift
func processImageData(completion: @escaping (Image?) -> Void) {
  loadWebResource("data-url") { dataResult in
    guard case let .success(data) = dataResult else {
      completion(nil)
      return
    }
    loadWebResource("image-url") { imageResult in
      // I got tired of typing
    }
  }
}
```

- Write asynchronous code as if it were synchronous
- Succint and easy to reason about

```
func processImageData() async throws -> Image {
  let dataResource = await try loadWebResource("some-url")
  let imageResource = await try loadWebResource("another-url")
  let imageTmp = await try decodeImage(dateResource, imageResource)
  let imageResult = await try resizeImage(image)
  return imageResult
}
```

General Concurrency

- What's wrong w/ this code?

```swift
func makeDinner() async throws -> Meal {
  let veggies = await try chopVegetables()
  let meat = await try marinateMeat()
  let oven = await try preheatOven()

  let dish = Dish(ingredients: [veggies, meat])
  return await try oven.cook(dish)
}
```

- It's not concurrent
- Waiting for each step to finish
- Let's fix it!

- `async let` makes separate, concurrently executing child tasks
- All async functions run as part of an async /task/
  - Carry schedule info like priority and act as interface for cancellation and such
- Try is written at call-site of the constant
- On completion, the constants are initialized

```
func makeDinner() async throws -> Meal {
  async let veggies = chopVegetables()
  async let meat = marinateMeat()
  async let oven = preheatOven()

  let dish = Dish(ingredients: await [try veggies, meat])
  return await try oven.cook(dish)
}
```

Actors

- Eliminate data races w/ compiler checks
- Set of limitations called `actor isolation`
  - For example, instance properties can only be accessed on `self`
  - Conversely, immutable value type properties don't require isolation
  - To call an instance method that mutates self, make that method `async`

Swift's Actor isolation plan

1. Basic isolation model
   - For value types only
   - value types are true copies and not references to the original object in memory, therefore, safer to deal with
2. Then full isolation model
   - for state in reference types etc

Actor classes

- Add `actor` keyword before class
- Atomic updates
- Enforce /actor isolation/ on mutable instance properties
- Internally, each class instance has something like its own queue

```
actor class BankAccount {
  // imagine this
  // private let backAccountQueue = DispatchQueue(name: "BankAccount", qos: .background)

  private let ownerName: String
  private var balance: Double

  // requires async
  func transfer(amount: Double, to other: BankAccount) async throws {
    balance = balance - amount
    await other.deposit(amount: amount)
  }
}
```

Global actor

- Don’t require limiting an actor to a specific class
- Annotations that can be fixed to variables and functions
- Singleton actor that **only** has one instance of a global actor in a given process
  - EG: `@UIActor` for main thread
- actor classes on the other hand can have many instances

```
// Usage
@UIActor func showUsers() {}

// Definition
@globalActor struct UIActor {
  static let shared = SomeActorInstance()
}
```

Languages and frameworks with Actors

- Akka framework (Scala)
- Erlang
- Pony

Language Comparison

- Go
  - Goroutines, locks, wait groups and more
- Rust
  - Borrow checker has great guarentees
  - Async/await, locks, channels
  - Verbose and less declarative (lower-level "older-brother" to Swift)
- Source

Go Example

```go
// Worker represents the worker that executes the job
type Worker struct {
  WorkerPool  chan chan Job
  JobChannel  chan Job
  quit        chan bool
}

func NewWorker(workerPool chan chan Job) Worker {
  return Worker{
    JobChannel: make(chan Job),
    quit:       make(chan bool)}
}

func (w Worker) Start() {
  go func() {
    for {
      select {
      case job := <-w.JobChannel:
        // ...
      case <-w.quit:
        // ...
      }
    }
  }()
}

// Stop signals the worker to stop listening for work requests.
func (w Worker) Stop() {
  go func() {
    w.quit <- true
  }()
}
```

— I think something similar can be done w/ `sync.WaitGroup`

— Source

In Swift?

```swift
actor class Worker {
  func do(job: Job) async {
    // ...
  }

  func stop() async {
    // ...
  }
}
```

— Also, Swift has generics 🙃

— Source

Conclusion

- Swift will jump to a top-class concurrent language, making it even better for Apple GUI platform development
  - Apple's push for distributed systems
- Swift's complexity will increase, so hopefully the pace will slow down after concurrency
  - `Progressive disclosure` helps
  - Worrying "Which feature to use?" is both a joy and a curse
- Swift won't replace Go, Rust, Java, Ruby etc, but instead complement them more
- More choice of concurrent-savvy languages is a win for us all
- If successful on Swift, Actors may spread to new languages

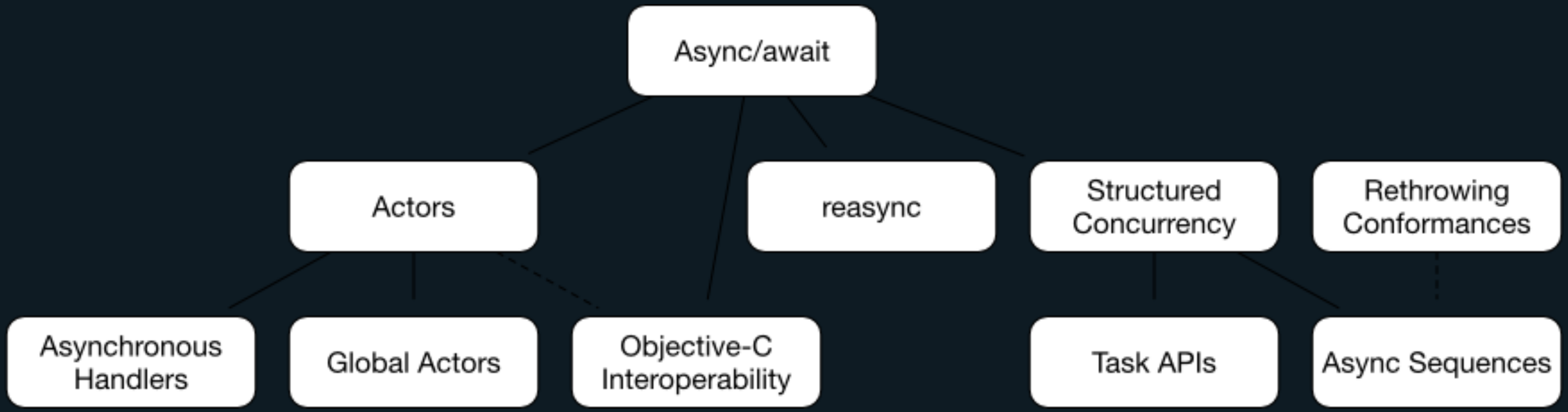
— If interested, try Swift!

Reference

- 2017 Swift Concurrency Manifesto
- Forums
- Roadmap
- Async/await
- Structured Concurrency
- Actors & actor isolation
- Actor memory isolation for “global” state
- “Actors are reference types, but why classes?”
- Evolving the Concurrency design and proposals
- Merged code
- Concurrency Roadmapから垣間見るSwiftの未来の一側面

Dependencies

- Source


Async/await
Actors
reasync
Structured Concurrency
Rethrowing Conformances
Asynchronous Handlers
Global Actors
Objective-C Interoperability
Task APIs
Async Sequences